NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Lined Waterway or Outlet

(Feet)

Code 468

DEFINITION

A waterway or outlet having an erosion-resistant lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to a designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

PURPOSES

To provide for safe disposal of runoff from other conservation structures or from natural concentrations of flow, without damage by erosion or flooding, where unlined or grassed waterways would be inadequate. Properly designed linings may also control seepage, piping, and sloughing or slides.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies if the following or similar conditions exist:

1. Concentrated runoff is of such that a lining is needed to control erosion.
2. Steep grades, wetness, prolonged base flow, seepage, or piping would cause erosion.
3. The location is of such that use by people or animals preclude use of vegetated waterways or outlets.
4. High-value property or adjacent facilities warrant the extra cost to contain design runoff in a limited space.
5. Soils are highly erosive or other soil or climatic conditions preclude using vegetation.
6. Installation of non-reinforced concrete or mortared flagstone linings, shall be made only on low shrink-swell soils that are well drained or where sub-grade drainage facilities are installed.

This practice is not applicable to watercourses where construction of a waterway would destroy woody wildlife cover and the present watercourse is capable of handling the concentrated runoff without serious erosion. Such situations are usually recognized by a meandering condition, steep side slopes that are stabilized by woody plants or herbaceous vegetation, and the watercourse is without rapidly advancing overfalls.

CRITERIA

Capacity. The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year-frequency storm. Velocity shall be computed by using Manning's Formula with a coefficient of roughness "n" as follows:

Lining	"n" Value
Concrete	
Trowel finish	0.012 to 0.013
Float finish	0.013 to 0.017
Gunite	0.016 to 0.022
Flagstone	0.020 to 0.025
Riprap	Determine from figure 1.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Indiana NRCS FOTG – August 1992.

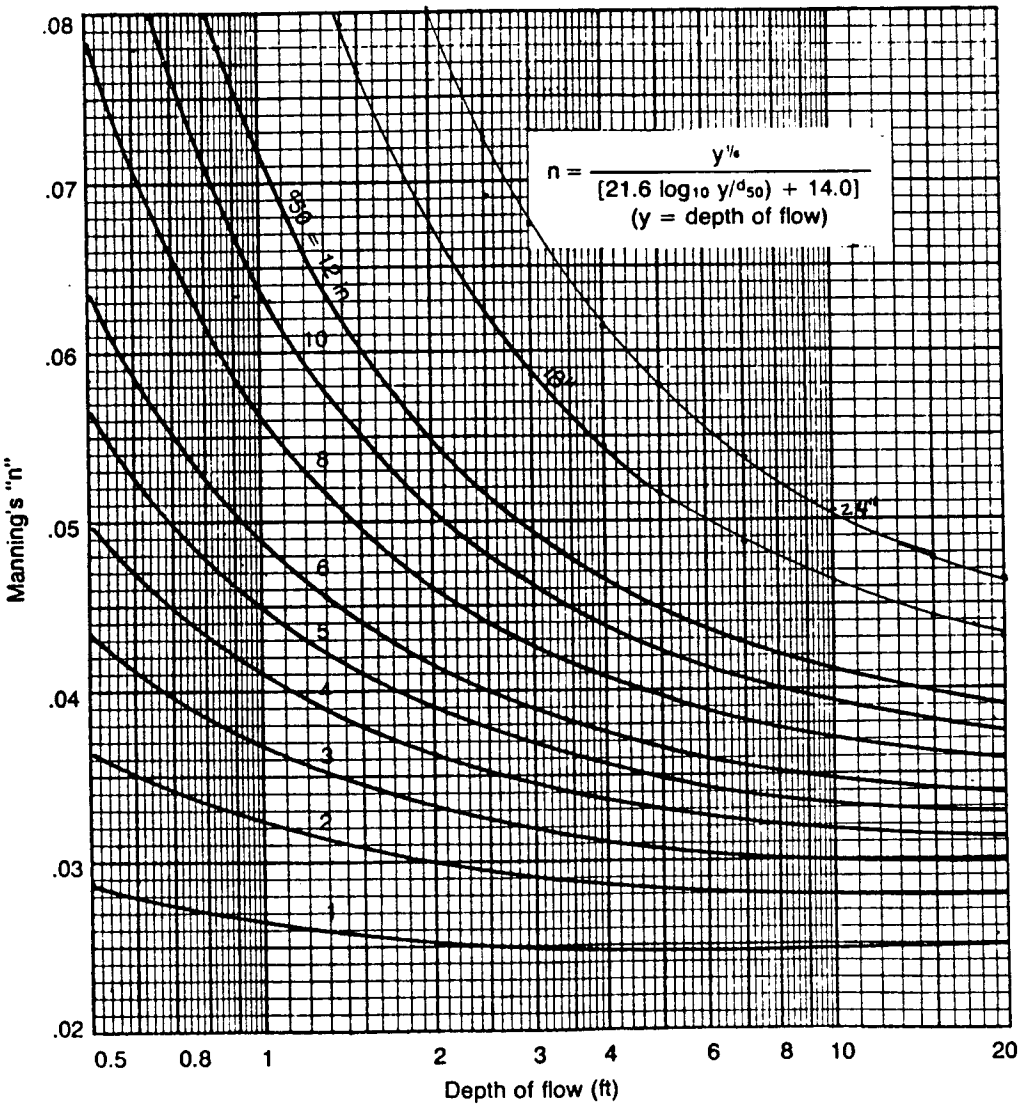

Figure 1. Values of n for riprap-lined channels, d_{50} size vs depth of flow.

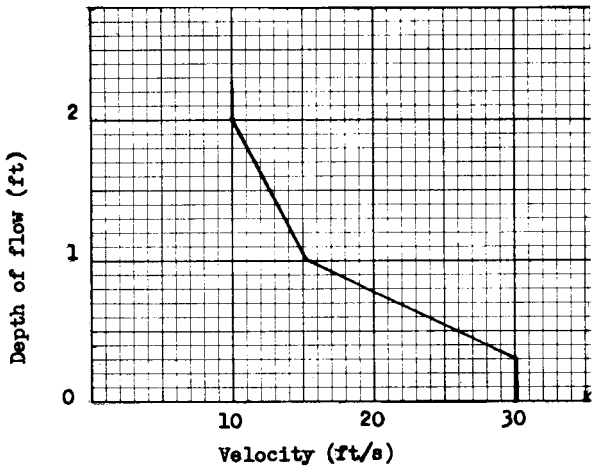

Figure 2. Maximum velocity vs depth of flow.

Velocity. Maximum design velocity shall be as shown in figure 2. Except for short transition sections, flow in the range of 0.7 to 1.3 of the critical slope must be avoided unless the channel is straight. Velocities exceeding critical shall be restricted to straight reaches.

Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipator to reduce velocity to less than critical.

Cross section. The cross section shall be triangular, parabolic, or trapezoidal. Cross sections made of monolithic concrete may be rectangular.

Freeboard. The minimum freeboard for lined waterways or outlets shall be 0.25 feet above design high water in areas where erosion-resistant vegetation cannot be grown adjacent to the paved side slopes. No freeboard is required if vegetation can be grown and maintained.

Side slope. The steepest permissible side slopes, horizontal to vertical, shall be:

Non-reinforced concrete:

Material	Height of Lining	Side Slope
Hand-placed, formed concrete	1.5 feet or less	vertical
Hand-placed, screened concrete or mortared in-place flagstone	less than 2 feet more than 2 feet	1 to 1 2 to 1
Slip form concrete	less than 3 feet	1 to 1
Rock riprap		2 to 1

Lining thickness. Minimum lining thickness shall be:

Material	Minimum Lining Thickness
Concrete	4 inches (in most problem areas, minimum thickness shall be 5 inches with welded wire fabric reinforcing).
Riprap	Maximum stone size plus thickness of filter or bedding.
Flagstone	4 inches including mortar bed.

Related structures. Side inlets, drop structures, and energy dissipaters shall meet the hydraulic and structural requirements for the site.

Filters or bedding. Filters or bedding shall be used to prevent piping. Drains shall be used to reduce uplift pressure and to collect water, as required. Filters, bedding, and drains shall be designed according to NRCS standards. Weep holes may be used with drains if needed.

Concrete. Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product shall be required. Specify a mix that can be certified as suitable to produce a minimum strength of at least 3,000 lb/in^2. Cement used shall be Portland cement, Types I, II or if required, Types IV or V. Aggregate used shall have a maximum size of 1½ inches.

Mortar. Mortar used for mortared in-place flagstone shall consist of a workable mix of cement, sand, and water with a water-cement ratio of not more than 6 gallons of water per bag of cement.

Contraction joints. Contraction joints in concrete linings, if required, shall be formed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet.

Provide for uniform support to the joint to prevent unequal settlement.

Rock riprap or flagstone. Stone used for riprap shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking.

CONSIDERATIONS

Effects on water quantity and quality shall be considered. This practice may have a minor effect on the quantity of surface and ground water. This practice will reduce the erosion in concentrated flow areas resulting in the reduction of sediment and substances delivered to the

receiving waters. When used as a stable outlet for another practice, lined waterways may increase the likelihood of dissolved and suspended substances being transported to surface water due to high flow velocities.

Water Quantity

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

2. Variability of the practice's effect caused by seasonal and climatic changes.

Water Quality

1. Filtering effects of vegetation on the movement of sediment and dissolved and sediment-attached substances will be evaluated.

2. Effects on the visual quality of the water resources.

3. Short-term and construction-related effects on the quality of water resources.

Special attention shall be given to maintaining and improving visual resources and habitat for wildlife where applicable. The landowner/user will be advised if wetlands will be affected and USDA/NRCS wetland policy will apply. All work planned shall be in compliance with General Manual Title 450-GM, Part 405, Subpart A, Compliance with Federal, State, and Local Laws and Regulations.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing lined waterways or outlets shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

Construction specifications

General. Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution will be minimized and held within acceptable limits. Construction methods that enhance wildlife will be used where practical. Trees, stumps, and brush removed from the construction area may be piled for wildlife habitat when approved by the landowner/user.

The completed job shall present a workmanlike appearance and conform to the line, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used.

Site preparation. All trees, stumps, brush, and similar materials are to be removed from the construction area and disposed of in a manner consistent with environmental concerns and proper functioning of the lined waterway.

Excavation. To the extent needed, all suitable materials removed from the specified excavation shall be used in the construction of the earth fill areas of the lined waterway. All surplus or unsuitable material shall be disposed of in a manner that will not interfere with flow into the lined waterway.

If possible, no spoil shall be deposited adjacent to the lined waterway unless such spoil and the adjacent area have a positive grade toward the lined waterway or inlets. The cross section shall be excavated to the neat lines and grades as shown on the plans.

Fill placement. The material placed in the fill areas or over-excavated areas of a lined waterway shall be free of sod, roots, frozen soil, stones over 8 inches in diameter, and other objectionable materials.

The distribution and gradation of soil materials shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. The work area shall be kept free of standing water when fill is being placed.

The placing and spreading of the fill materials shall be started at the lowest point of the

foundation and the fill shall be brought up in approximately horizontal layers not to exceed 9 inches in thickness. Each layer will be compacted by complete coverage with the hauling and spreading equipment.

Moisture control. The minimum moisture content of the fill material and foundation shall be such that when kneaded in the hand the fill material will form a ball that does not readily separate. The maximum moisture content is when conditions are too wet for efficient use of the hauling and compaction equipment.

Construction tolerances. The following are guidelines for lined waterway construction:

Trapezoidal Lined Waterway

Grade <2%	
Item	Tolerance
Depth at centerline	Grade to 0.2 feet below
Depth at toe	Grade to 0.2 feet above
Bottom width	10% wider not to exceed 2 feet
Grade >2%	
Item	Tolerance
Grade	Grade +10% of grade

Parabolic Lined Waterway

Grade <2%	
Item	Tolerance
Depth at centerline	Grade to 0.2 feet below
Top width	10% wider not to exceed 5 feet
Grade >2%	
Item	Tolerance
Grade	Grade +10% of grade

There will be no reverse grades. Trapezoidal lined waterways will be constructed so low flows remain in the center and the side slopes are nominally to grade with no unsightly humps of hollows.

Lining. Concrete linings shall be placed to the thickness shown on the plans and shall be finished in a workmanlike manner. Provisions shall be made to protect freshly placed concrete and to insure proper curing. Filter, bedding, and rock riprap shall be placed to line and grade in the manner specified. Riprap shall be placed so that it does not reduce the design section more than 10 percent.

Finish and cleanup. The lined waterway and designated spoil areas will be finished in a relatively smooth condition ready for seeding. All rocks 3inches in diameter or larger and roots shall be removed from the waterway and spoil area surfaces.

Vegetative establishment. Whenever possible, excess water shall be directed away from the lined waterway until vegetation is established. Any protective works shall be removed and the disturbed areas seeded to permanent grass after the lining in the lined waterway is established.

If needed, apply lime to raise the pH to the level desired for species of vegetation being seeded.

Fertilize according to soil tests or at a minimum rate of 1000 pounds of 12-12-12 fertilizer (or its equivalent) per acre as soon as the waterway has been constructed within the seeding periods. Applications of 150 pounds per acre of ammonium nitrate 6 to 8 weeks after seeding on soils low in organic matter and fertility on high velocity waterways with large drainage areas will greatly improve vegetation establishment.

Work the fertilizer and lime into the soil to a depth of 2 to 3 inches with a harrow or disk. Prepare a firm seedbed with a cultipacker or cultipacker type seeder.

Seed one of the following grass mixtures during the preferred seeding periods of March 1 to May 10 or August 10 to September 30.

Species	Minimum Rates of Pure Live Seed
1. Tall Fescue	35 lb/ac
2. Tall Fescue* Creeping red fescue	25 lb/ac (shaded sites) 10 lb/ac
3. Reed canary grass*	18 lb/ac
4. Kentucky bluegrass	40 lb/ac (urban areas)
5.Smooth bromegrass	35 lb/ac

Note: ¼ lb/ac of Ladino clover may be added to all but #4 of the above see mixtures.

*Adapted to poorly drained soils.

When construction is completed between May 11 and August 9, a temporary cover crop should be established using one of the following:

Species	Minimum Rates
(1) Wheat	150 lb/ac
(2) Rye	150 lb/ac
(3) Spring oats	100 lb/ac
(4) Annual rye grass	20 lb/ac
(5) Corn	150 to 300 lb/ac

After August 10 the temporary cover should be removed or incorporated, fertilizer applied, seedbed prepared and permanent seeding done in normal manner.

On critical sites mulch with 1½ to 2 tons straw per acre. Anchor the mulch with an asphalt spray, netting or a mulch anchoring tool, in accordance with practice standard (484) Mulching.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain capacity and vegetative cover. Items to consider are:

1. Do not graze lined waterway during establishment and when soil conditions are wet.
2. Protect lined waterway from damage by farm equipment and vehicles. Do not use lined waterway as a roadway and practice care when crossing to prevent tillage marks or wheel tracks.
3. Maintain constructed width by lifting or disengaging tillage equipment properly, and avoid farming operations along lined waterway that would hinder water entry.
4. Observe lining for any deterioration or movement of rock in riprap lined waterways. Perform needed maintenance as soon as possible to eliminate further deterioration or damage.
5. Do not spray with herbicides or cross lined waterways during spray operations unless the equipment is completely shut off.
6. Fertilize vegetated portions of lined waterways the first spring after seeding and thereafter as necessary to maintain a vigorous stand of grass. Caution should be used with fertilization to maintain water quality.
7. Mow vegetated portions of lined waterways regularly to maintain a healthy, vigorous sod. Time the first mowing after ground-nesting birds have hatched (about August 1). Remove excess top growth. Do not burn or overgraze.
8. Repair all broken subsurface drain lines adjacent to or in the waterway.
9. Re-establish vegetative cover immediately where scour erosion has removed established seeding or vegetated portion of lined waterway.
10. Maintain effective erosion control of the contributing watershed to prevent siltation and the resulting loss of capacity.